1997. The Journal of Arachnology 25:202–205

LEG AUTOTOMY AND AVOIDANCE BEHAVIOR IN RESPONSE TO A PREDATOR IN THE WOLF SPIDER, *SCHIZOCOSA AVIDA* (ARANEAE, LYCOSIDAE)

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ABSTRACT. The wolf spider, *Schizocosa avida* (Walckenaer 1838) can utilize leg autotomy to successfully avoid capture by the scorpion, *Centruroides vittatus* (Say 1821). Leg autotomy was used successfully in 7 out of 43 encounters with a scorpion (16%). Spiders were captured and eaten by scorpions in 79% of the encounters. Two spiders (5%) escaped capture by means other than leg autotomy. Scorpions most often grasped spiders at their abdomen (49%), followed by the cephalothorax (35%) and leg (16%). Naive spiders (no previous experience with a scorpion), with intact legs or an autotomized leg, spent significantly more time (26–32 min out of a 60-min trial) on a filter paper disc that had come into previous contact with a scorpion as compared to spiders that had lost a leg in a successful escape from an encounter with the predator (10 min). This is an example of associative avoidance learning and is the first demonstration of this type of learning in response to previous experience with a predator in spiders.

The autotomy of various bodily structures in response to attack by predators has been reported for many species (Robinson et al. 1970; Edmunds 1974). Tail autotomy has been shown to enhance survival in salamanders (Brodie 1983) and lizards (Punzo 1982; Arnold 1988). Decapod crustaceans (Spiviak & Politis 1989) and spiders (Foelix 1982; Formanowicz 1990) frequently autotomize their legs when grasped by predators.

In the present study, I analyzed the effectiveness of leg autotomy as an antipredator strategy in the wolf spider, *Schizocosa avida* (Walckenaer 1838), against a naturally occurring scorpion predator, *Centruroides vittatus* (family Buthidae). I also investigated the effects of previous encounters with the predator on the avoidance behavior of *S. avida*.

METHODS

I collected adult females of *S. avida* in Brewster County, Texas, during May–July 1994. Spiders carrying egg sacs were located at night using a headlamp. Scorpions (*C. vittatus*) from the same area were located using a portable UV light (BioQuip Model 2813C, Gardena, California). Animals were placed individually in plastic holding containers and transported to the laboratory for subsequent studies. Voucher specimens of *S. avida* and *C. vittatus* have been deposited in the University of Tampa Invertebrate Collection.

All experiments were conducted on adult female spiders (body length: 11–14 mm) reared from egg cases collected in the field. Spiderlings emerging from egg cases were reared in an environmental chamber (Percival Model I-37, Boone, Iowa) maintained at 20 °C, 68–72% relative humidity (RH), and a 12L:12D photoperiod regime. Spiderlings were housed individually in plastic containers and fed on a mixed diet of flies (*Drosophila melanogaster* and *D. virilis*) and cockroach (*Periplaneta americana*) nymphs. Water was provided *ad libitum*. As the spiders grew in size, larger prey were used (adult crickets, cockroaches and beetles). As a result of these rearing procedures, all spiders were naive in the sense that they had no prior experience with the scorpion, *Centruroides vittatus*, which is sympatric with *Schizocosa avida* in Brewster County, Texas. Adult female scorpions (0.419 g ±0.21) were maintained under the same conditions and fed on a diet of crickets, grasshoppers and a variety of spiders collected locally in Hillsborough County, Florida. Scorpions were deprived of food for 72 h prior to any encounter with a spider.

Encounter experiments.—Each encounter between a scorpion and a spider was conducted in a clear acrylic plastic (Plexiglass™) chamber (15 × 10 × 10 cm) at room temperature. The chamber was situated on a wooden table behind a one-way mirror to minimize disturbance to the animals during encounter sequences. The floor of the chamber contained 3 cm of sand as a substrate. All spiders used in these experiments were fed 24 h prior to an encounter with a predator, and possessed all of their legs. A scorpion was placed in the chamber for 24 h prior to an encounter with a spider. I staged a total of 50 encounters (trials) between different spiders and scorpions. Each spider and scorpion was tested only once. At the start of each trial, a spider was placed at the center of the encounter chamber which contained one randomly chosen scorpion. I carefully observed both animals and verbally recorded their activities using a Sony HP-110 tape recorder. In seven of the trials, the scorpions made no attempt to capture the spider. Only those data obtained from trials in which a scorpion attempted to capture a spider (n = 43) were used for statistical analysis. A trial ended when the spider was either successfully captured and ingested by a scorpion, escaped an initial strike without utilizing leg autotomy, or escaped via leg autotomy. Data were analyzed using the G-test of independence as described by Sokal & Rohlf (1981). All encounters were recorded on a Panasonic L3 video recorder for subsequent study as previously described by Punzo (1995).

Effect of previous encounter.—In a second set of experiments using different spiders and scorpions, I tested the effects of a previous encounter with *C. vittatus* on the subsequent behavior of three groups of *S. avida*. One group of spiders (G1, n = 15) consisted of individuals who had all of their legs intact and had never encounterd a scorpion throughout their lives. Another group (G2) consisted of 15 different spiders who had also never encountered a scorpion; in this group, however, one of their legs (chosen at random) was autotomized after being grasped by a pair of forceps. The third group (G3) consisted of 15 spiders who had one previous experience with a scorpion and had used leg autotomy to successfully escape capture by the predator. In these experiments, a spider was placed randomly into either end of a glass chamber (15 × 15 × 8 cm) containing two, square-shaped pieces of filter paper (Whatman No. 1) situated side-by-side and covering the entire floor of the chamber. One of the pieces of filter paper was taken from the floor of a plastic container housing a scorpion (treated), allowing *C. vittatus* to come into contact repeatedly with the filter paper during the course of its normal activities (for a period of two days). The other fresh piece of filter paper (untreated) had not been in contact with a scorpion. For each trial, the positions of the two pieces of filter paper (to the right or left) on the floor of the chamber was determined using a table of random numbers. The length of each trial was 60 min, and the amount of time (in min) spent by each spider on both pieces of filter paper was recorded with a stopwatch. A Duncan multiple range test (Sokal & Rohlf 1981) was used to analyze the data.

RESULTS

In encounters with scorpions, *S. avida* females were successfully captured and eaten in 79% of the trials (34 out of 43 trials). Nine spiders escaped capture; seven of these (78%) utilized leg autotomy. During prey capture, scorpions grasped the spider using one of their pedipalps. Spiders were either grasped by their abdomen (49%), cephalothorax (35%) or leg (16%). Only two of the nine spiders (22%) escaped capture without utilizing leg autotomy. These two spiders were grasped at the distal end of the abdomen and lateral region of the cephalothorax and escaped by pulling free from the pedipalps. Sixteen percent of the spiders were grasped by a leg and escaped after autotomizing the limb. Significantly more spiders escaped capture by utilizing leg autotomy than those who escaped by struggling free ($G = 34.9$, $df = 1$, $P < 0.001$). Scorpions were observed feeding on the autotomized leg while the spider ran to the other end of the chamber.

The effects of previous encounters with a predator on the subsequent behavior of *S. avida* are shown in Figure 1. There was no significant difference in the mean amount of time spent on a treated (contact with scorpion) versus untreated (no contact with scorpion) pieces of filter paper between G1 (legs intact, no previous encounter with predator) and G2 (leg autotomized, no previous experience) spiders ($P > 0.50$). However, spiders that had previously escaped by autotomizing a leg (G3) spent significantly less time on treated filter paper (10 min out of a 60 min trial) as compared to untreated filter paper (50 min) ($P < 0.001$).

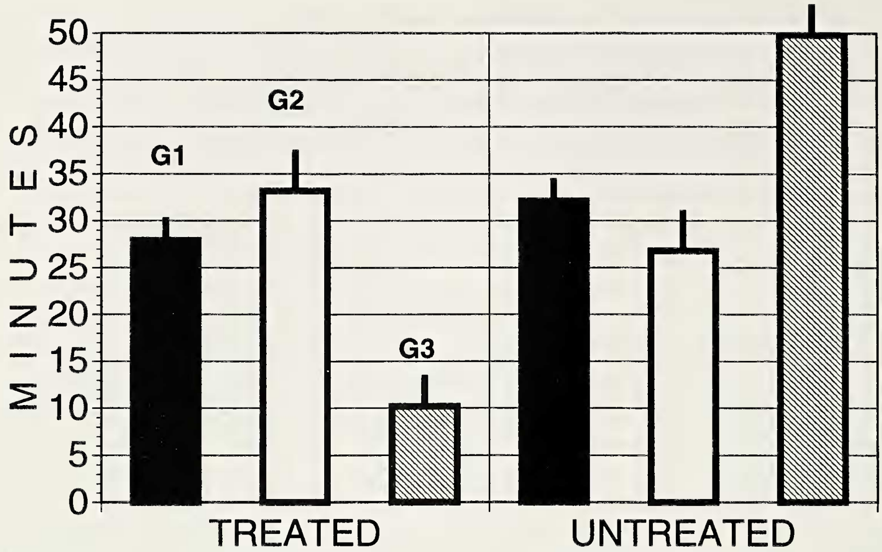

Figure 1.—The effects of previous encounter experience with the scorpion *Centruroides vittatus* on the behavior of three groups (G1, G2, G3) of *Schizocosa avida*. Values represent the mean amount of time (in minutes) that *Schizocosa avida* females remained on square pieces of filter paper that had been exposed to the presence of *Centruroides vittatus* (treated) as compared to discs that had not been contacted by the scorpion (untreated). G1 = spiders with legs intact, no previous experience with a scorpion; G2 = leg autotomized, no previous experience with a scorpion; G3 = leg autotomized in an encounter with a scorpion. Vertical lines represent SD. See text for details.

DISCUSSION

This study demonstrates that *S. avida* can utilize leg autotomy to escape capture by a natural predator if grasped by the leg. A previous study by Formanowicz (1990) showed that a filistatid spider, *Kukulcania hibernalis* (Chamberlin 1926) from Wise County, Texas, was also able to utilize leg autotomy to escape predation by *C.entruroides vittatus*. However, this strategy was not an effective defense against a centipede predator (*Scolopendra polymorpha*). In the present study, leg autotomy resulted in a successful escape in 16% of the encounters for the wolf spider *S. avida*, whereas *K. hibernalis* successfully utilized this strategy in 36% of its encounters with a scorpion.

The site of autotomy was always at the junction (intersegmental membrane) between the coxa and trochanter of the leg grasped by the scorpion. This is in agreement with the previous literature on leg autotomy in spiders (Robinson et al. 1970; Foelix 1982) and some insects (Pearson 1985). In all cases, once the spider was grasped by a scorpion, it exhibited a rapid upward movement of the coxa. The rest of the distal portion of the leg remained in a relatively fixed in position.

This study also shows that once *S. avida* has had an encounter experience with *C. vittatus* and is successful in escaping capture, it will avoid a substrate that has been previously occupied by this scorpion. This suggests that the spider can remember some cue (probabaly olfactory in nature) associated with the scorpion and use that information to avoid the predator at a later time. This is an example of rapid associative avoidance learning (Punzo 1985, 1996) and represents the first demonstration that a spider can utilize this type of behavioral plasticity to avoid predators. Although this spider and scorpion have presumably coexisted sympatrically for a long period of time, there is no indication that *S. avida* possesses an innate capacity to recognize the presence of this predator. Spiders that had no previous encounter experience with the scorpion did not demonstrate avoidance of a substrate previously occupied by *C. vittatus*.

ACKNOWLEDGMENTS

I thank T. Punzo for assistance in field collecting, A. Jenzarli for statistical consultation, and C. Bradford, J. Berry, P. Sierwald, and anonymous reviewers for reading an earlier draft of this manuscript. I also thank the University of Tampa for a Faculty Development Grant which made much of this work possible.

LITERATURE CITED

Arnold, E.N. 1988. Caudal autotomy as a defense. Pp. 237-273, *In* Biology of the reptilia. Vol. 16 (C. Gans & R.B. Huey, eds.). Alan Liss, New York.

Brodie, E.D. 1983. Antipredator adaptations of salamanders: evolution and convergence among terrestrial species. Pp. 109-133, *In* Plant, animal and microbial adaptations to terrestrial environment. (N.S. Margaris & R.J. Reiter, eds.). Plenum Press, New York.

Edmunds, M. 1974. Defense in animals. Longman, London.

Foelix, R.F. 1982. Biology of spiders. Harvard Univ. Press, Cambridge, Massachusetts.

Formanowicz, D.R. 1990. Antipredator efficcy of spider leg autotomy. Anim. Behav., 40:400–401.

Pearson, D.L. 1985. The function of multiple antipredator mechanisms in adult tiger beetles (Coleoptera: Cicindelidae). Econ. Entomol., 10:65–72.

Punzo, F. 1982. Tail autotomy and running speed in the lizards, *Cophosaurus texanus* and *Uma notata*. J. Herpetol., 16:329–331.

Punzo, F. 1985. Recent advances in behavioral plasticity in insects and decapod crustaceans. Florida Entomol., 68:89–104.

Punzo, F. 1995. The biology of the spider wasp, *Pepsis thisbe* (Hymenoptera: Pompilidae) from Trans Pecos Texas. I. Adult morphometrics, larval development and the ontogeny of larval feeding patterns. Psyche, 101:229–241.

Punzo, F. 1996. Localization of brain function and neurochemical events associated with learning in insects. Recent Trends in Comp. Biochem. Physiol. (in press).

Robinson, M.H., L.G. Abele & B. Robinson. 1970. Attack autotomy: a defense against predation. Science, 169:300–301.

Sokal, R.R. & F.J. Rohlf. 1981. Biometry. 2d ed. W.H. Freeman, San Francisco, California.

Spiviak, E.D. & M.A. Politis. 1989. High incidence of limb autotomy in a crab population from a coastal lagoon in the province of Buenos Aires, Argentina. Canadian J. Zool., 67:1976–1985.

Manuscript received 19 June 1996, accepted 10 November 1996.